REPORT

2016 GAY MINE REMEDIAL INVESTIGATION DATA SUMMARY REPORT

Gay Mine Remedial Investigation
Fort Hall Indian Reservation
Fort Hall, Idaho

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June 7, 2017

Project No. 103-93418-16.001.900

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ACRONYMS AND ABBREVIATIONS

95UCL	95% upper confidence limit
ALS	ALS Environmental Laboratory
amsl	above mean sea level
ASA	Administrative Settlement Agreement and Order on Consent
BA	Background Area
bgs	below ground surface
COPC	constituent of potential concern
CV	coefficient of variation
DSR	Data Summary Report
DU	decision unit
EL	East Limb
ESL	ecological screening levels
gpm	gallons per minute
HHSL	human health screening level
HQ	Headquarters
ISM	incremental sampling methodology
J	Estimated
J+	Estimated with high bias
J-	Estimated with low bias
MCL	maximum contaminant level
MDLs	method detection limits
mg/kg	milligrams per kilogram
mg/L	milligram per liter
MSPs	mill shale piles
NTU	nephelometric turbidity unit
OBDA	Overburden Disposal Area
OBDU	Overburden Decision Unit
pic/L	picocuries per liter
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RIWP	Remedial Investigation Work Plan
RPD	relative percent difference
RSD	relative standard deviation
RSL	Regional Screening Level
S40	South 40
SOW	scope of work
SU	sampling unit
TDS	total dissolved solids
TKN	total kjeldahl nitrogen
TOC	total organic carbon
TSS	total suspended solids
U	Non-detect
UCL	upper confidence limit
µg/kg	microgram per kilogram
USDA	United States Department of Agriculture
EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator

1.0 INTRODUCTION

This Data Summary Report (DSR) has been prepared by Golder Associates Inc. (Golder) on behalf of the J.R. Simplot Company (Simplot) and FMC Corporation (FMC) ("The Companies"). The report has been prepared in accordance with the requirements of the Administrative Settlement Agreement and Order on Consent (ASA) Scope of Work (SOW) for Performance of a Remedial Investigation and Feasibility Study (RI/FS) for the Gay Mine in southeastern Idaho.

1.1 Purpose and Scope

The purpose of this DSR is to describe field activities and present results for Remedial Investigation (RI) work completed during 2016 at the Gay Mine. An RI Work Plan (RIWP) was prepared by Golder which describes the overall RI work to be performed at the Gay Mine (Golder 2014). During 2015, the first phase of site investigations was completed. Results were presented in the 2015 DSR (Golder 2016a). An RIWP Addendum was prepared based on the results of the 2015 DSR (Golder 2016b) and the Quality Assurance Project Plan (QAPP) was updated to reflect work in both the RIWP and the RIWP Addendum (Golder 2016c). Some of the work conducted during 2016 was based on work presented in either the original RIWP (Golder 2014) or in the 2015 RIWP Addendum (Golder 2015b), which had been previously approved. A summary of COPCs for all environmental media sampled at Gay Mine as listed in the QAPP (Golder 2016c) is provided in Table 1.1-1. The United States Environmental Protection Agency (EPA) provided approval via email communications (Wallace 2016a, 2016b) to proceed with all of the new investigations proposed in the 2016 RIWP Addendum with specific requested modifications to some of the sampling activities. EPA did not agree with the approach presented in the RIWP Addendum to evaluating adequacy of overburden data collected. As of the date of this DSR, formal written approval of the Final 2016 RIWP Addendum and revised QAPP has not been provided.

The sampling conducted during 2016 was designed to address additional data needs based on previous investigations to determine nature and extent of contamination and aid in refining risks to receptors. Work during 2016 was conducted according to the draft QAPP (Golder 2016c) and supplemental EPA email approvals (with conditions noted in the following bulleted list), and included the following activities:

- Surface water sampling
- Bird mud nest materials sampling
- Soil sampling of five Overburden Disposal Units (OBDUs) using incremental sampling methodology (ISM)
- Vegetation and discrete soil sampling for:
  - ISM sampling for dominant vegetation during the early part of the growing season on all OBDUs sampled in the fall of 2015, as well as on the five additional OBDUs Disposal Units. ISM vegetation samples were also collected from the five new OBDUs later in the growing season. (EPA requested that triplicates be collected in at least 20% of the areas for the spring vegetation sampling to complement the fall 2015 vegetation

sampling, as well as one triplicate for the 5 new OBDUs proposed for soil sampling. In addition, EPA requested that known selenium accumulator species not be excluded from ISM sampling if encountered and locally dominant.)

- Selenium accumulator species and co-located discrete soil sampling
- Culturally-significant species (EPA requested the addition of dandelions and thistle leaves and requested that co-located soil samples be collected)
- Riparian species (EPA requested that co-located soil samples be collected with vegetation samples, and that they be analyzed for those analytes that exceed screening levels. All soil samples to be archived for potential future analysis)

- Willowstick Technologies geophysical survey in the South 40 Area
- Groundwater monitoring well installation and sampling

1.2 Report Organization

This DSR includes the following sections:

- Section 1.0 – presents the purpose of this report
- Section 2.0 – presents a description of the field work performed during 2016
- Section 3.0 – presents a summary of the results of the field work completed during 2016
- Section 4.0 – presents a summary of data requirements based on the results of the field work to include in an RIWP Addendum for work to be implemented during 2017
- Section 5.0 – provides the signature page for the authors of the report
- Section 6.0 – provides references cited in the report

2.0 DESCRIPTION OF FIELD WORK COMPLETED DURING 2016

2.1 ISM Soil Sampling of Overburden Disposal Areas

Supplemental ISM soil sampling was conducted at overburden disposal areas, as identified in the 2016 RIWP Addendum (Golder 2016b).

2.1.1 ISM OBDU Sampling Locations

Five additional overburden decision units (OBDUs) were sampled during 2016: two each in the North Limb and East Limb, and one in the South 40. ISM OBDUs sampled during 2016 are shown in Figure 2.1-1. The following is a list of the OBDUs where ISM samples were collected:

- **North Limb OBDUs:**
  - OBDU-2 – topsoil near mill shale pile (MSP) M3 (sampled in triplicate)
  - OBDU-10 – no topsoil, near MSP A6
- **East Limb OBDUs:**
  - OBDU-15 – topsoil, near MSP X2 (plus one field duplicate sample)
  - OBDU-18 – no topsoil, near MSP DD2A
- **South 40 OBDU:**
  - OBDU-22- topsoil, near MSP G2

2.1.2 ISM Soil Sampling Procedures

The overburden area soil samples were collected using the ISM approach, as described in Attachment B of the 2015 QAPP (Golder 2015c). The ISM approach characterizes environmental media that are composed of a heterogeneous assemblage of particles (ITRC 2012) to ensure that the samples and aliquots drawn from each medium are representative of the overall particle contributions in the medium by eliminating or minimizing biases in the sampling processes. The media were allocated into decision units (DUs) (i.e., a single unit area for which a decision is made) To be consistent with the ISM soil samples previously collected, each DU selected for supplemental sampling is a 5-acre parcel.

Three replicate samples of 30 increments were collected from OBDU-2 (randomly selected prior to field work), and one sample of 30 increments was collected at each of the other four OBDUs. Increment locations were identified by developing randomly-started, systematic square grids for each ISM sample set, with three sets of coordinates for each of the three replicate samples collected at OBDU-2. Each coordinate location was identified in the field to indicate its corresponding replicate sample number (1, 2, or 3). At each of the increment locations, one soil increment was collected from the 0- to 3-inch depth horizon, and a separate soil increment was collected from the 3- to 12-inch depth horizon. As soil increments were collected, they were placed in the sample container corresponding to its replicate number and depth interval. One QC field duplicate sample was collected at OBDU-15. Additionally, one equipment blank was collected from decontaminated reusable equipment between ISM samples per the frequency noted in Section 2.5 of the 2016 QAPP (Golder 2016c). Decontamination of equipment was performed per the protocol included as Attachment B to the 2015 QAPP (Golder 2015c).

Soil samples were collected to ensure that the same volume of material from each increment (regardless of the depth of excavation) was collected at each increment location. This was achieved by placing each soil increment into a measuring container to check volume prior to placing the soil increment into its appropriate ISM sample container. All 30 increments for each of the samples in each of the two depth horizons were combined in each of the DU/sampling units (SUs) for a total of 14 samples as follows:

- OBDU-2 – One sample of 30 increments from each of two depth intervals at three replicate locations for a total of six ISM samples.
- OBDU-10 – One sample of 30 increments from each of two depth intervals for a total of two ISM samples.
- OBDU-15 – One sample of 30 increments from each of two depth intervals for a total of two ISM samples. In addition, one field duplicate ISM sample was collected at this OBDU.
- OBDU-18 – One sample of 30 increments from each of two depth intervals for a total of two ISM samples.
- OBDU-22 – One sample of 30 increments from each of two depth intervals for a total of two ISM samples.

When excavating the 3- to 12-inch depth horizon, there were some instances when an abrupt textural change was observed or refusal occurred and excavation was discontinued. These instances were noted in the field notebooks (Appendix A) and are documented on the sample maps (Figures 2.1-2 through 2.1-6).

The ISM samples were shipped to the laboratory for ISM sample preparation and sub-sampling to derive aliquots representative of the sample for analysis for the constituents of potential concern (COPCs) listed on Table QAPP-1 in the 2016 QAPP (Golder 2016c). At the laboratory, an aliquot was pulled from each sample for pH, total solids, and total organic carbon (TOC) analyses (on the bulk fraction) prior to sample drying. Next, the samples were dried and sieved for analysis of the 2 mm size fraction. The samples were then spread on a tray as a "slabcake" and gridded into 30 laboratory increments. Sub-samples were collected from each grid location on the slabcake, and each subsample was composited into a laboratory aliquot for analysis. Analyses were conducted on each replicate and depth interval. Results for the ISM samples are discussed in Section 3.1 and presented in Table 3.1-1.

2.2 Vegetation and Discrete Soil Sampling

Vegetation sampling during 2016 included sampling of dominant vegetation and accumulator species during the early part of the growing season (as described in Section 5.3 of the RIWP [Golder 2014] and modified in Section 2.2.1 of the 2016 Gay Mine RIWP Addendum [Golder 2016b]) as well as sampling for riparian species and culturally-significant species. The approach for collecting samples of riparian and culturally-significant species is presented in the RIWP Addendum (Golder 2016b). Shoots from non-woody ISM, riparian, and accumulator species (i.e. grasses and shrubs) were clipped at ground level. Leaves or needles from near the end of the branch were collected for woody species. Specific plant parts used by the Shoshone-Bannock Tribes were collected for culturally significant plants (Shoshone-Bannock Tribes 2014). Samples were collected either using a ceramic scissors or by tearing the herbaceous above ground portion of the plant. Laboratory analysis of the vegetation samples were conducted for the list of analytes presented in Section 5.1 of the RIWP (Golder 2014) and presented in Tables 3.2-1 through 3.2-4 of this report.

Vegetation and discrete soil sampling conducted during 2016 included the following:

- Dominant vegetation ISM sampling was conducted during the early part of the growing season (June and July) at all DUs (MSPs, OBDUs, and Background) that had been sampled during the fall of 2015, as well as the five new OBDUs. In addition, ISM sampling was conducted late in the growing season (end of August) for the five new OBDUs (see Section 2.1.1).
- Accumulator species and co-located soil samples were collected throughout the disturbed and background areas during the early part of the growing season for most species. Some species were not identifiable during the early part of the growing season (e.g., *woody aster [Machaeranthera* and *Symphyotrichum* species]) and were the focus of the late season sampling efforts, and conversely, flowers for some species were only present during the early part of the growing season and not present later in the year (e.g., *Astralagus*, *Haplopappus*, and *Mentzelia*).
- Culturally significant species and co-located soil samples were collected throughout disturbed areas. Sampling was conducted during July and September for the majority of plants to correspond with the time of year the Tribes indicated they typically collect the plant parts for the species sampled. Dandelions (*Taraxacum*) were collected in late May since this was when they were abundant across the Site.
- Riparian species and co-located soil samples were collected during July from areas potentially impacted by the Site as well as background areas (along streams located upgradient of potential site impacts).

Field notes for vegetation sampling conducted during 2016 are provided in Appendix A. Vegetation sampling results are discussed in Section 3.2 and presented in Tables 3.2-1 through 3.2-4.

2.2.1 ISM Dominant Vegetation Sampling

Dominant vegetation sampling using ISM was completed between May 28 and June 10, 2016 for DUs that had been sampled in the fall of 2015, as wells as the five new ISM soil sampling OBDUs (Figure 2.1-1). The five new OBDUs were sampled again during August 30 to September 1, 2016 to provide data late in the growing season. The dominant plant ISM sampling was performed as presented in Section 2.2.1 of the 2016 RIWP Addendum (Golder 2016b), as well as Section 2.1.2 and Section 2.2.2 of the 2016 QAPP (Golder 2016c). Additionally, only one ISM replicate was collected for some of the DUs, instead of three as were collected during the fall 2015 collections. Three replicates were collected from one of the five new OBDUs, which represents 20% of the new OBDUs sampled in 2016. OBDU-2 was randomly chosen prior to the field work for collection of three replicates. This modification was made due to the low variability between the fall 2015 replicates collected (see Appendices N-2 and N-3; Golder 2016a) and was approved in an email from Joe Wallace (Wallace 2016a). In particular, there was low variability for molybdenum and selenium which were the only dominant vegetation analytes that exceeded ecological screening levels (ESLs) in the disturbed areas during fall 2015 collections.

ISM collection methodologies can be found in Attachment B – ISM Sample Collection Protocol of the 2015 QAPP (Golder 2015c). Vegetation increments were collected using either ceramic scissors or by manually tearing the herbaceous above-ground portion of the plant. Each increment sample was approximately 5 grams (totaling about 150 grams for each ISM sample of 30 increments). Soil and dust was removed physically in the field during collection as well as in the lab prior to collection. Additionally, the lab rinsed the vegetation samples prior to analysis according to their standard operating procedures.

Required field Quality Assurance/Quality Control (QA/QC) samples (i.e., equipment blanks and field duplicates) were collected at the frequency outlined in Attachment A of the 2015 QAPP (Golder 2015c). Decontamination of equipment used to collect vegetation samples followed the procedures outlined in Attachment A of the 2015 QAPP (Golder 2015c). Analysis methods are provided with the results in Table 3.2-1.

2.2.2 Accumulator Vegetation Species and Discrete Soil Sampling

Selenium accumulator vegetation species collections were completed between May 27 and June 11, July 20 to July 27, and August 31 to September 1, 2016. Discrete vegetation samples for known selenium accumulator species (listed in Table QAPP-24 [Golder 2015c]) were collected from disturbed areas across the Site and in background areas. With each plant species collected, a discrete sample of soil from the 3 to 12 inch depth at each location was also collected. Samples of each selenium accumulator species were collected from the disturbed areas of the Site, from as many different soil types as possible (e.g., overburden disposal areas, MSPs with and without topsoil, background areas, etc.). These accumulator species samples were analyzed individually for the list of vegetation COPCs, along with a co-located soil sample to determine soil-to-plant uptake factors for each plant collected. Up to ten known selenium accumulator species and co-located soil samples were collected in the disturbed areas of the Site, and a similar number of these species along with co-located soil samples in background areas.

Samples were collected in accordance with the Gay Mine Site Protocol for Field Collection of Discrete Plant Samples provided in Attachment A of the 2015 QAPP (Golder 2015c). Vegetation samples were either cut using ceramic scissors or by manually tearing the herbaceous above ground portion of the plant. For non-woody species, the shoots were collected (clipped at ground height). For woody species, leaves or needles were collected near the end of a branch. If the desired species had edible fruiting bodies, that portion was collected in addition to the leaves/needles or shoots. Each discrete sample was approximately 20 grams. If more than one plant was required to be collected to obtain a full 20 gram sample, samples were collected from individuals of the same plant species within an area of about 1 meter. Some samples were gently shaken to remove any larger soil residue upon collection. Each collected sample was placed into an individual sampling container for submittal to the laboratory for analysis as discrete samples, in accordance with the packing and chain-of-custody procedures detailed in the QAPP (Golder 2016c). The lab rinsed the vegetation samples prior to analysis according to their standard operating procedures.

Required field QA/QC samples (i.e., equipment blanks and field duplicates) were collected at the frequency outlined in Attachment A of the 2015 QAPP (Golder 2015c). Decontamination of equipment used to collect vegetation samples followed the procedures outline in Attachment B of the 2015 QAPP (Golder 2015c). Analysis methods are provided with the results in Table 3.2-2.

2.2.3 Riparian Vegetation Species and Discrete Soil Sampling

Riparian vegetation species collections were completed between July 19 and 26, 2016. Riparian vegetation was sampled from several areas across the Site and in background areas to determine concentrations of COPCs in riparian plants at Gay Mine that may be impacted from mine activities. Our initial sampling was conducted at locations where the fall 2015 sampling event (Golder 2016a) identified high concentrations of selenium in the sediment and/or water. There are no extended tracts of wetlands at the Gay Mine site, but there are local occurrences of riparian vegetation along wet areas. The locations selected for the 2016 sampling were biased toward those found to be wet during the fall 2015 sampling event, to maximize the potential for riparian vegetation to be present. Based on these criteria, the following onsite and offsite surface water and sediment sampling locations were proposed for riparian vegetation sampling (Figure 3.2-3):

- 004A: Cattle Pond above O/P Pit
- 013: A-12 Pit Lake
- 014: Big Willow Springs
- 020: Big Springs (offsite)
- 025: Z Pit Lake
- 030: East Limb North Pond / Holding pond below “Y” intersection
- 031: Portneuf River above U Creek (offsite)
- 037: Ross Fork Creek
- 040: Seep east of OBDU-11

These locations were surveyed specifically for riparian vegetation, including but not limited to species that require large amounts of water such as: willow (*Salix spp.*), stinging nettle (*Urtica dioca*), sedges (*Carex* *spp.*) and rushes (*Juncus spp.*). Species identified for separate sampling as selenium accumulators (i.e. Aster sp.) or culturally-significant species (i.e. chokecherries and thistles) were collected as part of those sampling efforts (Sect 2.2.3 [Golder 2016b]), rather than as part of this riparian vegetation sampling event. Botanists who have conducted previous vegetation surveys and collections at the Site performed this sample collection. When riparian vegetation was located, vegetation samples of the three most dominate riparian species were collected. Samples were collected in accordance with the Gay Mine Site Protocol for Field Collection of Discrete Plant Samples provided in Attachment A of the 2015 QAPP (Golder 2015c). Vegetation samples were either cut using ceramic scissors or by manually tearing the herbaceous above ground portion of the plant. For non-woody species, the shoots were collected (clipped at ground height). For woody species, leaves or needles were collected near the end of a branch. Each discrete sample was approximately 20 grams. If more than one plant was required to be collected to obtain a full 20 gram sample, samples were collected from individuals of the same plant species within an area of about 1 meter. Some samples were gently shaken to remove any larger soil residue upon collection. Each collected sample was placed into an individual sampling container for submittal to the laboratory for analysis as discrete samples, in accordance with the packing and chain-of-custody procedures detailed in the QAPP (Golder 2016c). The lab rinsed the vegetation samples prior to analysis according to their standard operating procedures.

Co-located soil from the 3-12 inch depth was collected and analyzed for those COPCs that exceeded screening levels in the vegetation.

Required field QA/QC samples (i.e., equipment blanks and field duplicates) were collected at the frequency outlined in Attachment A of the 2015 QAPP (Golder 2015c). Decontamination of equipment used to collect vegetation samples followed the procedures outline in Attachment B of the 2015 QAPP (Golder 2015c). Analysis methods are provided with the results in Table 3.2-3.

2.2.4 Culturally Significant Species Vegetation and Discrete Soil Sampling

Culturally significant vegetation species were collected during June 10 and 11, July 20 to July 27, and on August 31, 2016. The different collection dates corresponded to availability of plant parts sampled and when they would likely be collected by tribal members. The goal of the culturally-significant plant collection was to be able to collect information on the concentrations of COPCs in plants at the Gay Mine Site that are used by Tribal members. The Tribes have provided a list of culturally-significant plants, parts, and routes of exposure that are collected at or near the Gay Mine Site as Table M-1 of the “Shoshone-Bannock Exposure Scenario for Use in Risk Assessment: Traditional Subsistence Lifeways” document (Shoshone-Bannock Tribes 2016). Summer and fall surveys of plants at the Site were conducted to determine the presence and relative abundance of culturally significant species at Gay Mine. Survey results are summarized in the 2014 and 2015 DSRs (Golder 2015a, Golder 2016a). Table 2.2-2 of the 2016 RIWP Addendum (Golder 2016b) lists the observed frequency of occurrence of culturally-significant plants across all survey areas at the Site from both of these surveys. The rationale for 2016 collections are present in the 2016 RIWP Addendum (Golder 2016b). Per request from EPA, co-located soil from the 3-12 inch depth was collected at each plant sample location.

Samples were collected in accordance with the Gay Mine Site Protocol for Field Collection of Discrete Plant Samples provided in Attachment A of the 2015 QAPP (Golder 2015c). Vegetation samples were either cut using ceramic scissors or by manually tearing the herbaceous above ground portion of the plant. For non-woody species, the shoots were collected (clipped at ground height). For woody species, leaves or needles were collected near the end of a branch. If the desired species had edible fruiting bodies, that portion was collected in addition to the leaves/needles or shoots. Each discrete sample was approximately 20 grams. If more than one plant was required to be collected to obtain a full 20 gram sample, samples were collected from individuals of the same plant species within an area of about 1 meter. Some samples were gently shaken to remove any larger soil residue upon collection. Each collected sample was placed into an individual sampling container for submittal to the laboratory for analysis as discrete samples, in accordance with the packing and chain-of-custody procedures detailed in the QAPP (Golder 2016c). The lab rinsed the vegetation samples prior to analysis according to their standard operating procedures.

Required field QA/QC samples (i.e., equipment blanks and field duplicates) were collected at the frequency outlined in Attachment A of the 2015 QAPP (Golder 2015c). Decontamination of equipment used to collect vegetation samples followed the procedures outline in Attachment B of the 2015 QAPP (Golder 2015c). Analysis methods are provided with the results in Table 3.2-4.

As indicated in the 2016 RIWP Addendum (Golder 2016b), plants were only collected from disturbed areas during 2016. Results are discussed in Section 3.2.4.

2.2.5 Opportunistic Wildlife Observations During Vegetation Sampling

During 2016 vegetation assessments, Golder ecologists recorded incidental wildlife observations. Observations included documenting species encountered while accessing vegetation assessments areas and while traversing around the Site. Species included in these observations include the following species:

- Black bear (*Ursus americanus*).
- Coyote (*Canis latrans*).
- Rocky Mountain Elk *(Cervus canadensis nelsoni*) observed in area south of BA 11.
- Moose (*Alces alces*).
- Mountain Bluebird (*Sialia currucoides*).
- Mule Deer (*Odocoileus hemionus*) present near BA 11.

- Red Tail Hawk (*Buteo jamaicensis*).
- Ground squirrel observed near MS J2A.
- Idaho Giant Salamander (*Dicamptodon aterrimus*) - dead along bank of the Z Pit Lake
- In addition to the wildlife observations, two dead cattle cows were observed by the Golder vegetation sampling crew on July 20 near station 004A (cattle pond east of the O/P pit).

Later in July ranchers reported finding 8 dead cattle in the North Limb Area near Lincoln Creek Road. Danielle Gunn from the University of Idaho Fort Hall Extension Office investigated and sampled liver and rumen contents from one of the cows, nearby surface water, and alfalfa. Samples were sent to the Utah Veterinary Diagnostic Laboratory for analysis. Elevated concentrations of selenium were found in the rumen, liver, and alfalfa samples, and the animal was described as being severely deficient in copper and deficient in zinc (Hall 2016). The elevated selenium concentrations are described by Hall (2016) as follows:

- Rumen concentration was 91.98 parts per million (ppm) compared to recommended dry matter intake for cattle of up 0.3 ppm with recommended maximal safe at 5.0 ppm. Based on typical rumen material make-up, the dry weight concentration would have likely been >200 ppm.
- Liver concentration was 2.87 ppm compared to expected normal range of 0.25 to 0.50 ppm. Hall described the liver content as high enough to potentially cause chronic selenosis if prolonged increases were present, but not high enough to be associated with acute poisoning. Chronic selenosis can occur at >1.50 ppm. Acute selenium poisoning can occur at concentrations > 7.0 ppm.
- Alfalfa samples ranged from 0.60 ppm to 80.11 ppm compared to concentrations common in the intermountain west of < 0.40 ppm.
- Additionally, patches of western aster were sampled and had concentrations ranging from 1,946 to 5079 ppm.

2.3 Surface Water Investigations

2.3.1 Surface Water Sampling Locations and Procedures

Surface water samples were collected from May 11 through May 20, 2016. A total of 35 sites were sampled, 2 duplicates and 2 blanks were also collected. All sites that had water were sampled and locations were the same as 2015 with the exception of 024 and 048. Site 024 was initially incorrectly sampled on the Portneuf River below the confluence with Baker Creek, this sample was processed and an additional sample from above the confluence was also collected and processed, labeled as site 024A. Site 048 was a new site added near the spring box below OBDA 11, downstream of site 040. Figure 2.3-1 shows the sample locations. All sampling efforts including daily calibration of field equipment were documented in a field notebook, presented in Appendix A. Photographs were taken at the majority of sites and are presented in Appendix B.

Surface water samples were collected using two different methods dependent on type of water body. For flowing water, a peristaltic pump was used. Tubing and filters were used for one site and then disposed of as non-hazardous waste. For pit lake and pond sites, disposable Nalgene™ containers provided by the analysis laboratory were used to collect four subsamples of water from four quadrants of the water body. This sample was mixed in the Nalgene™ bottle and then the peristaltic pump was used to fill sample bottles. The only mine pit lakes to contain water (A12, W and Z) were all <15 feet deep and too shallow for stratification. Therefore, only surficial samples were collected as was described in the 2014 RI Work Plan (Golder 2014).

Further specifics of the sampling procedures are outlined in the QAPP (Golder 2016c). No decontamination was required as all sampling materials used were disposable and only used for one sampling event. A field blank for unfiltered samples and an equipment blank for filtered samples were collected in association with the surface water samples to represent field conditions and to establish if there was any contamination contributed by the dedicated equipment. These blanks were collected at a rate that met the 1 in 20 frequency described in Section 2.5 of the QAPP (Golder 2016c).

2.3.2 Opportunistic Wildlife Observations During Surface Water Sampling

The field crew observed the following livestock and wildlife during the course of surface water sampling, and cattle use was evident at all locations and only noted if cattle were present during sampling:

- Cattle were in the vicinity of site 018 on Ross Fork Creek.
- Cattle and ground squirrels were in the vicinity of site 015 on Willow Creek.
- Cattle have been inside the fence surrounding site 026, Queedup Springs, but were not present during spring sampling. Ground Squirrels were in area.
- Elk were present approximately ¼ mile downstream of site 048, the new location below OBDA 11.
- Evidence of coyote, elk, and cattle (e.g. presence of tracks and scat) in the vicinity of site 040, but not present during sampling.
- Elk were present north of site 043.
- A variety of birds including swallows, starlings, and mallards were observed at and near site 013.
- Tadpoles and a dead salamander were present at site 029. Swallows were nesting in the cliff around the Pit Lake. There were also unidentified animal burrows present, measuring approximately 1 foot wide.
- Elk were observed on top of pit wall at site 025. Birds including falcon-like bird, swallows, songbirds, and ducks were in the area. Beetles and other macroinvertebrates were observed in the Pit Lake.
- Fish approximately 3 inches in length were observed near site 023.
- Small fish were observed near site 024, also many different birds were in the area.
- Small fish were observed near site 034, frogs were noted in marshy areas around creek.
- Hummingbirds were present near site 020 and a fish (approximately 6 inches long) was observed in the large pool where the sample was collected at the head of the spring.
- Hummingbirds and vultures were observed near site 021. Ungulate tracks present in area, but no animals observed during sampling.

- Cattle were located in vicinity of site 022.
- Frogs were present near site 024A.
- Macroinvertebrates and tadpoles were observed in water at site 010. Many birds were also present at the site. Ungulate tracks were present in area, but no animals were observed during sampling.
- Macroinvertebrates were noted in water at site 011, also many birds were present at the site. Ungulate tracks were present in area, but no animals were observed during sampling.
- Macroinvertebrates were observed in water at site 012, also many birds were present at the site. Ungulate tracks were present in area, but no animals were observed during sampling.
- Macroinvertebrates were noted in water at site 030, also many birds were present at the site. Ungulate tracks were present in area, but no animals were observed during sampling. Cattle were observed using the pond.
- A coyote was present at site 041.
- Ungulate tracks were present near site 045, but no animals were observed during sampling.
- Ungulate tracks were present near site 042, but no animals were observed during sampling.
- Elk and deer were observed in the area near site 007.
- Ungulate tracks were present near site 004A, but no animals were observed during sampling. Old cattle bones were present in the vicinity as well as three recently deceased cattle. A red tailed hawk was circling overhead when we arrived.
- Ungulate tracks were present near site 038, but no animals were observed during sampling.
- Small rodents, amphibians, and birds were using the area near site 035. Cattle ranchers were driving a herd through the area near site 035 during sampling. Old cattle bones were observed in area.
- A dead cow was observed in the South 40 area near wells that were installed in 2015.
- A dead cow was observed in the A12 Pit Lake.

2.4 Bird Mud Nest Material Sampling

2.4.1 Bird Mud Nest Sampling Locations and Procedures

Bird nesting materials were collected as composite samples from three locations based on observations of nesting sites in previous years. Figure 2.4-1 shows the sample locations.

Site 049 was inside the old tire shop at headquarters. At two areas of the tire shop an extendable pole was used to knock nests that appeared to be uninhabited from the rafters onto a plastic sheet. Material was collected from the sheet using a spoon in accordance with the sediment sampling methods presented in the QAPP (Golder 2016c).

Both sites 050 and 051 were in the north limb near OO-3 pit. In this area, the nests were located on a loose rocky cliff face in an area too high to safely access for direct sampling. Material was selected for analysis based on mud presence and proximity to nests. Site 050 was west of observed nests and 051 was east of the nests. At both locations small subsamples of mud material were collected from the area to make a composite sample.

At all three sites, the nests were built and no active mud collecting was observed.

2.4.2 Opportunistic Wildlife Observations During Nest Sampling

Swallows were observed in the vicinity of all sample collection sites. Site 049 is heavily used by the birds and many nests were still occupied. At sites 050 and 051, swallows were present in the area but were not observed entering or leaving the nests.

2.5 Groundwater Well Installation and Sampling

This section details the monitoring well installations and groundwater sampling conducted during 2016. Work proposed for 2016 included installation of three Phase 2 wells in the South 40, and three Phase 1 wells in the southern portion of the North Limb Area (east of the Headquarters Area) of the Site. However, work was halted due to weather conditions and only one well was installed during 2016 (see Section 2.5.2). Groundwater sampling included all Phase 1 South 40 wells, which were sampled in the spring and the new well installed during 2016, which was sampled after it was installed in the fall. The purpose and objectives of this work are detailed in the 2016 RIWP Addendum (Golder 2016b).

2.5.1 Willowstick Geophysics Survey

A geophysical investigation was performed in June 2016 by Willowstick Technologies, LLC. The objective of the investigation was to test the hydrogeologic electrical geophysical technique within the South 40 Mining Area. The study was conducted to provide information on potential preferential groundwater flow paths and contaminant transport away from the South 40 JD/JF Pit Lake area, as well as to confirm the proposed Phase 2 monitoring well locations. The complete report is provided in Appendix C and summarized below.

- Three surveys were completed to investigate potential flow directions and perspectives based on the size of the study area and the anticipated hydrogeological conditions.
- The underlying principle of Willowstick's methods relies on mapping subsurface electrical currents using advanced magnetic field sensing technology and using these data to determine groundwater flow paths (i.e., electrical current signature is measured and modeled to interpret preferential groundwater flowpaths).
- The results show that in the vicinity of the Pit Lake, electric current, and therefore suggest that groundwater flow paths, move downward vertically and to the east.
- To the north and south of the Pit Lake, groundwater may occur along an approximate north-south trending geologic feature that may provide connectivity with the regional groundwater system.
- Groundwater flow may follow this inferred geologic feature, flowing to the south on the southern portion of the pits and to the north on the northern portion of the pits.

- The proposed MS-S40-1 well location is positioned to potentially intersect the groundwater flow to the north and the proposed MW-S40-2 well location is positioned to potentially intersect the groundwater flow to the south.

QAPP Table 14 – DQO 8 provides data quality objectives (DQOs) for this study (Golder 2015c). The result of the study was consistent with Outcome 7b of the DQO, which was that the effectiveness of the technique was uncertain and needs to be tested with additional new wells before it will be applied to other mining areas. Due to the uncertainty of the study under the conditions found at the pit lake, additional investigation using this technique has been suspended.

2.5.2 Well Drilling and Installations

The 2016 drilling program did not begin until September 2016, due in part to delays in approval of the 2016 RIWP Addendum (Golder 2016b). Drilling ended in November 2016 because of weather. Over this time period, one well was drilled and completed (MW-S40-3) and a second well (MW-S40-1) was partially drilled.

The wells were drilled and installed by Thomas Drilling, Inc. (Afton, Wyoming) using a Schramm 685 Air-Rotary drill rig. A Golder field geologist was onsite to provide oversight and direction. The boreholes were logged by a Golder geologist by inspecting drill cuttings, monitoring drill action, and communicating with the driller.

MW-S40-3 was drilled to 618 feet below ground surface (bgs). The bottom of the well was set at 617 feet bgs, with a screen interval from 595 to 615 feet bgs. The well was constructed with 4-inch diameter galvanized steel casing from the ground surface to 495 feet bgs and stainless steel casing and screen below 495 feet bgs. A 20-slot interval (0.020 inch) was used for the well screen. The gravel pack was Colorado 10x20 silica sand. The well was sealed using a bentonite plug and a bentonite/cement grout slurry. A detailed well log and well construction diagram is included with the borehole logs in Appendix D.

The MW-S40-1 borehole was drilled to 167 feet bgs (with casing) before the 2016 drill program was ended. A cap was welded to the top of the casing, with the intention of additional drilling and completing the well in 2017. The well locations are shown on Figure 2.5-1. The well log for the portion of MW-S40-1 drilled so far is included with the borehole logs in Appendix D.

The groundwater levels bgs and elevations above mean sea level (amsl) measured in 2016 (spring and fall) are provided in Table 2.5-1 and are shown on Figure 2.5-1. The drilling and well completion details at individual wells are provided below.

2.5.2.1 Summary of Geologic Conditions

The geologic conditions encountered in each borehole are described in the well logs (Appendix D). MW-S40-3 was drilled in the center of the JG-1 Pit, approximately 800 feet southeast of MW-JG-1-1, which was installed in 2015 (Figure 2-5.1). The geologic conditions in the upper 150 to 200 feet of MW-S40-3 were similar to those observed in MW-JG-1 and consisted mainly of fine-grained material (silts and clays) with occasional gravel-to-boulder sizes in discrete zones. This is inferred to be mainly pit backfill material. Between 180 and 200 ft bgs there is uncertainty as to whether the borehole was intersecting weathered bedrock or boulder-sized bedrock clasts mixed with fill material near the bedrock surface. MW-S40-3 intersected competent bedrock at approximately 200 feet bgs. The bedrock consisted of a mix of siltstone, sandstone and limestone, and is inferred to be part of the Wells Formation.

MW-S40-1 was drilled on the northern portion of the South 40 area, approximately 200 to 300 feet west of the estimated boundary of the JC-1 pit and approximately 300 feet southwest of MW-JC1-1 (installed in 2015). The upper 50 to 55 feet of the MW-S40-1 borehole was unconsolidated material, most likely fill material from the adjacent JC-1 pit. Below 55 feet, the borehole intersected wells formation bedrock, which was generally similar to the Wells Formation material found in MW-S40-3 (Appendix D).

2.5.2.2 Summary of Hydrogeologic Conditions

The monitoring wells drilled in 2015 found small amounts of isolated perched groundwater occurring near the pit bottoms in the JF2 and SA1 pits and below the S6 stockpile in the South 40 area. The saturated thickness was less than 30 feet and production rates from these wells was very low, ranging from 0.4 to 2.4 L/min and the wells being repeatedly pumped dry during well development even at these rates. No perched groundwater was found in two other wells drilled in 2015 to depths of 270 to 400 feet in the JC pit (northern portion of the South 40) and JG Pit (southern portion of the South 40). The wells were sampled again during spring 2016. Hydrogeologic conditions were similar in these wells in spring 2016 when compared to fall 2015 (i.e., wells that were dry in fall 2015 were also dry in spring 2016). When present, perched groundwater was 3 to 14 feet higher in spring 2016 than measured in fall 2015, which suggests that some seasonal recharge is occurring. The perched groundwater is found at approximately 90 to 130 feet bgs or 5,540 to 5,560 feet amsl (Table 2-5.1). A shallow well (MW-TM-1) was also installed in 2015 adjacent to Willow Creek, an ephemeral drainage south of the SA-1 pit. Groundwater in this well is found at approximately 16 feet bgs (5,655 feet amsl).

The drilling and sampling conducted in 2015 indicate limited occurrence and apparent lack of hydraulic connectivity of the perched groundwater system (Golder 2016). For example, 3 of the wells drilled in 2015 did not intercept perched groundwater and have remained dry. The 3 wells with perched groundwater present show very limited production rates and the variability in water elevations between the wells indicate a lack of hydraulic connectivity. The hydrogeologic conceptual model following the 2015 program was that potential contaminants in groundwater (if present) would likely migrate into and be transported in the regional groundwater system. The regional groundwater system was believed to occur within the Wells formation, at depths of approximately 500 to 600 feet bgs. The objective of the 2016 drilling program was to install a series of monitoring wells in the regional groundwater system.

During the 2016 drilling program, no perched groundwater was encountered in either well and the MW-S40-1 well was dry down to 167 feet bgs when drilling was terminated for the season. Groundwater in MW-S40-3 was initially intersected between approximately 600 and 612 feet bgs, occurring in a zone of predominantly fractured siltstone. Upon well completion, the static water level was 579.5 feet bgs. Although the well elevation has not yet been surveyed, the measured water level translates to approximately 5,167 feet amsl, which is at least 375 feet below the groundwater elevations found in any of the wells installed in 2015. Airlift rates of approximately 20 gallons per minute (gpm) were sustained during borehole development. The depth of groundwater and geologic information collected during drilling indicate that the well is completed in the Wells formation in the regional groundwater system. Groundwater flow directions and gradients could not be determined as only one well was installed.

2.5.3 Well Development

The MW-S40-3 well was developed by Thomas Drilling on October 6 and 7, 2016. The well was developed by surging and bailing using a 5-gallon stainless steel bailer. Approximately 300 gallons were bailed from the well using this method. Water clarity improved quickly during development and reached 11.2 nephelometric turbidity unit (NTU) at the end of development.

2.5.4 Groundwater Sampling

Groundwater quality samples were collected in the spring of 2016 from the Phase 1 South 40 Wells (MW-TM1-1, MW-SA1-1, MW-JF2-1, and MW-S6-1) between May 23 and 25, 2016. The one new well installed during 2016 (MW-S40-1) was sampled on November 8, 2016.

One equipment blank and one duplicate sample was collected during each round of sampling, meeting the 1 in 20 sample frequency provided in the QAPP Section 2.5. The fall samples were collected with a bladder pump using low-flow sampling methods. MW-S40-3 was sampled by bailing with a dedicated plastic bailer within approximately 24 hours following well development. Filtered and unfiltered samples were collected. Samples were filtered in the field using a peristaltic pump. Field parameters were collected and recorded after parameters stabilized in spring 2016 and at the end of well development in fall 2016. Decontamination procedures were followed as described in the 2015 QAPP (Attachment A, TG-1.2-20). Analyses performed and results are provided on Table 3.5-1. Samples were submitted for analyses of the parameters listed in Table QAPP 3 (Golder 2016c).

3.0 SUMMARY OF RESULTS

This section provides a summary and discussion of the sample results. A data validation summary and review is provided in Appendix E.

3.1 ISM Soil Sampling Results for OBDUs

This section provides the results for ISM sampling from five OBDUs. Results are provided in Table 3.1-1. The ISM sample results for the 2 mm particle size fraction are presented for chemical results, and for the as-received fraction (not sieved) for physical parameters (pH, percent solids, and TOC). An evaluation of the replicate results for OBDU-2 (the only OBDU in the 2016 dataset where triplicates were collected) is provided in Section 3.1.1. An overall comparison of the replicate ISM samples is provided in Section 3.1.2 to evaluate the precision and representativeness of the ISM data.

Section 3.1.3 describes the exploratory data evaluations, including box plots, and radar graphs, that were performed for the ISM soil sample results from the OBDUs. Evaluation is provided of ISM sample results from sampling of OBDUs in 2015 and 2016. The ISM results are compared to screening criteria in Sections 3.1.4. Estimates of radiological isotope concentrations are calculated and compared to screening criteria in Section 3.1.5.

As stated above, exploratory data evaluations, including development of box plots and radar graphs, were performed for the ISM soil sample results to compare the results for the areas, mine features, and background to each other. Exploratory data evaluation detail is provided in Appendix F.

3.1.1 ISM Replicate Comparisons for OBDU-2

The overall results for the three ISM replicates collected from OBDU-2 were tested for reproducibility, precision and accuracy using relative standard deviation (RSD) and relative percent difference (RPD) calculations. The calculations are presented in Table 3.1-2.

RSD, also known as coefficient of variation (CV), used the results of the three ISM replicates to evaluate the reproducibility of the data. The RSD provides an estimate of the precision, but not necessarily the accuracy of the data. The RSD results are compared to lower target goal of 20% and an upper target goal of 35% (typically used in data validation for duplicate sample comparison).

RPD is used to evaluate the precision of the ISM results by comparing each of the three replicates to one another (i.e., replicates 1 vs 2, replicates 1 vs 3, and replicates 2 vs 3). The RPD results are compared to a RPD upper target goal of 35% and a lower target goal of 20%. The RPD results can be examined to evaluate whether one of the replicate results is out of range compared to the other two sets of replicate comparisons. For example, if the RPD for replicates 1 & 2 is within the target goal, but the RPDs for replicates 1 & 3 and 2 & 3 are above the target goal; it might indicate that replicate 3 is the cause of the RPD target goal exceedance (relative to the other two replicates).

Table 3.1-2 provides the RSD and RPD calculations for the replicate set of the results for ISM soil samples collected from OBDU-2. The RSDs and RPDs are calculated for the replicate ISM data to evaluate the representativeness of the ISM data under the rationale that consistent results within replicate sets indicate that the data are representative of the entire feature sampled using the ISM approach. The RSDs and RPDs results are summarized in Table 3.1-3 as follows:

Table 3.1-3: Summary of RSD and RPD Results for Metals Results in OBDU-2

Mine Feature	RSD Exceeds 35% (Y/N)	RSD Exceeds 20% (Y/N)	RPD Exceeds 35% (Y/N)	RPD Exceeds 20% (Y/N)
OBDU-2	N	N	N	N

The RSDs for the 2016 OBDU soil samples are all less than 15%, with an average RSD of 9.5% and 4.2% for deep and shallow soils, respectively. The RPDs for the various replicate sets are all below 10%, with an average RPD of 3.0% and 1.3% for deep and shallow soils, respectively. These results indicate that there is little variability in the 2016 dataset, and that the replicates are representative of their OBDU.

3.1.2 ISM Replicate Comparisons for all OBDU Data

In accordance with the 2016 RIWP Addendum (Golder 2016b), the data from the OBDU soil collected in 2016 were compared to the OBDU soil data collected in 2015 to determine whether the resulting 95% upper confidence limit (95UCL) are affected by the additional data. Data are considered sufficient if the 95UCL for each data set (2015 data only versus 2015 and 2016 data combined) does not increase or decrease by more than 20% percent and does not affect whether or not the 95UCL exceed screening levels. The comparisons were conducted for the 2 mm size fraction only, as that is the only size fraction collected in 2016.

The triplicate ISM soil samples conducted in 2015 were intended to allow calculation of 95UCLs. However, it is not necessary that triplicate samples be collected at all ISM soil locations. As discussed in the Interstate Technology Regulatory Council (ITRC) guidance on ISM (ITRC 2012), triplicate ISM samples are collected as one of the quality assurance measures to allow evaluation of the representativeness of the ISM data by comparison of RPDs between replicates. As suggested in a percentage of DUs (e.g., 10 to 20 percent) is normal to allow the testing of representativeness.

In the event that single replicate samples are collected at some DUs, it is appropriate to compare those single results against the 1st replicate of DUs that have triplicate results, where the first sample is the DU sample, and the second and third samples are the quality control replicates of that sample. That is the rationale behind the calculation of RPDs for all replicate 1 samples collected in 2016 for comparison against all replicate 1 samples (2015 only data compared against 2015 and 2016 combined data). In addition to comparing 1st replicate samples, RPDs were also calculated for all replicates (2015 only data versus 2015 and 2016 combined data) in order to identify any differences in the all replicate analysis compared to the replicate 1 analyses.

Table 3.1-4 presents the calculations of both Student's t and Chebychev 95UCLs (ITRC 2012) for each constituent in the datasets listed below:

- 2015 OBDU soil data only, replicate 1 only, deep soils
- 2015 and 2016 OBDU soil data combined, replicate 1 only, deep soils
- 2015 OBDU soil data only, all replicates, deep soils
- 2015 and 2016 OBDU soil data combined, all replicates, deep soils
- 2015 OBDU soil data only, replicate only, shallow soils
- 2015 and 2016 OBDU soil data combined, replicate 1 only, shallow soils
- 2015 OBDU soil data only, all replicates, shallow soils
- 2015 and 2016 OBDU soil data combined, all replicates, shallow soils

Table 3.1-5 presents the RPDs for the 95UCLs which were calculated for comparison of the following datasets:

- 2015 OBDU soil data only compared to 2015 and 2016 combined OBDU soil data, replicates 1 only, deep soils
- 2015 OBDU soil data compared to 2015 and 2016 OBDU soil data combined, all replicates, deep soils
- 2015 OBDU soil data only compared to 2015 and 2016 combined OBDU soil data, replicates 1 only, shallow soils
- 2015 OBDU soil data compared to 2015 and 2016 OBDU soil data combined, all replicates, shallow soils

The RPDs for these datasets are all below 20%, which indicates that the 2015 and 2016 combined data are within the range of variability of the 2015 only data, and therefore do not lend an upward or downward bias to the 2015 data. The following summarizes the RPD of the 95UCLs results

- The RPDs for deep soils, replicate 1 only, ranged between 13% and 14% for silver, and between 5.0% and 8.2% for antimony, cadmium, manganese, mercury, selenium, uranium, and vanadium. The RPDs for all other constituents were less than 5%.
- The RPDs for deep soils, all replicates, ranged between 6.9% and 7.9% for silver. The RPDs for all other constituents were less than 5%.
- The RPDs for the shallow soils, replicate 1 only, ranged between 15% and 16% for silver, between 11% and 13% for cadmium, and between 6.9% and 11% for antimony, cadmium, manganese, uranium, and vanadium. The RPDs for all other constituents were less than 5%.

- The RPDs for the shallow soils, all replicates, ranged between 7.3% and 8.6% for silver, and between 5.0% and 5.9% for cadmium. The RPDs for all other constituents were less than 5%.

These results indicate that the 2016 OBDU soil data are consistent with the 2015 OBDU soil data and can be included in the overall OBDU soil dataset. Screening level exceedances were not affected by the additional soil data collected in 2016, as described further in Section 3.1.4.

3.1.3 Exploratory Box Plots for ISM Soil Data

Appendix F contains two sets of exploratory box plots for the ISM soil data (Figures F-1 and F-2). The boxplots allow a quick comparison of the ISM soil data from the different sample types between areas of the Site and the deep and shallow soils. Each of the boxplot sets contains a legend that describes the terminology used to describe the boxplot (e.g., whiskers, quartiles, and outlying data points). Figures F-3 presents radar graphs of the OBDU soil data for each constituent by location. The radar graphs illustrate which OBDUs contribute the lowest and highest constituent concentrations and, as they are presented in consecutive order (corresponding mostly to their north to south layout), to understand whether there is a geographical pattern to the concentrations observed.

Comparison of 2015 Replicate 1 Data to 2016 Replicate 1 Data for Shallow and Deep Overburden Soils

Figure F-1 presents a comparison of the combined shallow and deep results for replicate 1 only of 2 mm OBDU soil data, comparing the 2015 results (95UCLs) to the 2016 results (raw data for sites without three replicates) to discern whether there are any large discrepancies in the 2016 data relative to the 2015 data. The data used in Appendix F-1 are the replicate 1 samples for all OBDUs sampled in 2015 compared against the replicate 1 samples for all OBDUs sampled in 2016. The second and third replicates from the 2015 OBDUs (and the one 2016 OBDU) were not used in these box plots because the inclusion of the extra two replicate results would overly influence the means in these box plots.

The upper ranges of constituents (e.g., upper quartiles, upper whiskers, or upper outlying data points) for the 2016 data are within the upper ranges of the 2015 data with these exceptions: antimony, boron (slightly higher), cadmium, chromium, copper, mercury, silver, thallium, uranium, vanadium, and zinc. As shown in Figure F-3, in every case where 2016 OBDU soil data exceeded all 2015 OBDU soil data (except for boron), the exceedances occurred in OBDU-15 and OBDU-18, which are both located in the East Limb. Boron exceeded 2015 data in OBDU-18 only.

Comparison of 2015 Overburden Soil Results to 2015 and 2016 Combined Data for Deep and Shallow Overburden Soil, Grouped by Region

Figure F-2 presents a comparison of the deep and shallow OBDU soil results for all replicates from the 2015 only data set (as presented in Appendix L-4 of the 2015 DSR [Golder 2016a]) and the 2015 and 2016 combined data set (all replicates), grouped by region (North Limb, East Limb, and South 40). The boxplots show various combinations of data for the deep (3- to 12-inch depth) and shallow (0-to 3-inch depth) samples.

The selenium results in the Appendix F-2 box all fall within the same range as those presented in the Appendix L-4 box plots (for 2 mm soils); except the deep soils for the combined 2015 and 2016 box plot (Appendix F-2) shows outliers within the same range as the quartiles in the 2015 box plot (Appendix L-4)..

The East Limb results have values that exceed any observed values in the North Limb and South 40 in both deep and shallow soils (unless noted) for the following constituents: antimony, arsenic, boron, cadmium, chromium, copper, manganese (shallow only), mercury, molybdenum, silver, thallium, uranium, vanadium, and zinc. For all of these constituents, the exceedance over the other land areas are due primarily to concentrations observed in OBDU-15 and OBDU-18, except boron (OBDU-18 only) and manganese.

The North Limb results have values that exceed any observed values in the East Limb and South 40 in both deep and shallow soils (unless noted) for the following constituents: aluminum, barium, beryllium, cobalt, lead, manganese (deep only), and nickel. The South 40 results exceed the observed values in the North Limb and East Limb for selenium only,

Comparison of Soil Concentrations by OBDU

Figure F-3 presents the radar graphs displaying the OBDU ISM soils results to illustrate which OBDUs contribute the lowest and highest constituent concentrations, and as they are presented in consecutive order (corresponding mostly to their north to south layout) to understand whether there is a geographical pattern to the concentrations observed."

As described in the discussion of boxplot results, OBDU-15 and OBDU-18 (from the 2016 data) contain constituent concentrations for 14 of the 21 constituents analyzed that are higher than the constituent concentrations observed in the other OBDUs. Similarly, OBDU-11, also located in the EL, contains elevated concentrations of the same 14 constituents (less manganese, plus nickel).

OBDU-9, located in the NL, contains elevated constituent concentrations (relative to the other OBDUs) of arsenic, chromium, mercury, molybdenum, nickel, silver, and zinc; all in shallow soils only. OBDU-4, also in the NL, contains elevated constituent concentrations of barium, cobalt, and manganese.

In summary, the OBDU soil results for 2016 compared within the criteria established in the work plan (Golder 2016b) are acceptable to be included in the overall OBDU dataset. The comparison of 95UCLs for the 2016 data compared to the 2015 data indicate that the 2016 data was within an acceptable range of variability of concentrations for OBDUs, and are therefore representative. However, several constituent concentrations in OBDU-15 and OBDU-18 are higher than the observed concentrations in other OBDUs. This is consistent with other relatively high concentrations of the same constituents in OBDU-11, also located in the EL.

Some of the COPCs exhibit highly variable concentrations in the overburden and there are not currently sufficient data to calculate site-wide mean concentrations for these constituents with high statistical confidence.

3.1.4 Comparison to Screening Levels

Table 3.1-1 presents the analytical results for metals concentrations for the five OBDUs sampled during 2016 compared against ecological (ESLs) and human health screening levels (HHSLs). All of the constituents exceed one or both of their respective criteria with the exception of barium and beryllium. Chromium, copper, lead, and molybdenum results do not exceed the HHSLs, but have exceedances of ESLs. The constituents observed in the 2016 data with non-exceedances of ecological and HHSLs are the same as those observed in the 2015 OBDU soil data.

3.1.5 Radiological Isotopes

There was no measurement of radiological isotopes in soil during 2016. For the purposes of a screening-level evaluation, we assume that all of the uranium measured is the U-238 isotope and the rest of the radionuclides are present according to secular equilibrium using modified Bateman Equations (Bateman 1910) presented in the 2015 DSR and copied here for consistency.

Bateman Equations:

$$\frac{dN_d}{dt} = \lambda_p N_p - \lambda_d N_d$$

Where

$$\lambda = \frac{\ln(2)}{t_{1/2}}$$

Secular equilibrium occurs when $\frac{dN_d}{dt} = 0$

$$\lambda_d N_d = \lambda_p N_p$$

$$N_d = \frac{\lambda_p N_p}{\lambda_d}$$

$$N_d = \frac{t_{1/2}^d}{t_{1/2}^p} \times N_p$$

Where

$$N = \frac{M}{MW}$$

Therefore,

$$\frac{M_d}{MW_d} = \frac{t_{1/2}^{d}}{t_{1/2}^{p}} \times \frac{M_p}{MW_p}$$

$$M_d = \frac{t_{1/2}^{d}}{t_{1/2}^{p}} \times \frac{MW_d}{MW_p} \times M_p \qquad \text{Equation 1}$$

Where:

- N – number of moles (unitless)
- λ – gamma coefficient (unitless)
- $t_{1/2}$ – half-life (years) (Table 3.1-6)
- MW – molecular weight (g/mole) (Table 3.1-6)
- M – Mass of radionuclide (g)

Table 3.1-6 shows the parameters that are used in the modified Bateman Equation. The radionuclide half-life values were used from the EPA Regional Screening Level (RSL) Radionuclide calculator (EPA 2016). Table 3.1-6 shows the estimated concentrations of the radionuclides in the measured soil samples based on this theory.

The ESLs were derived from the biota concentration guides (BCG: DOE 2002), and are the same as the ones used in the 2015 DSR (Golder 2016a). Table 3.1-6 shows that none of the estimated radionuclide concentrations exceed ecological BCGs.

Table 3.1-6 shows the HHSLs from the EPA RSL Radionuclide calculator (EPA 2016), as previously provided in the Screening Level Parameter document (Golder 2015d). All of the estimated radionuclide concentrations exceed the RSLs for all of the radionuclides for both the background and site samples. The assumption that all of the uranium measured in soil is present as the U-238 isotope is overly conservative, but the exact amount of U-238 or other isotopes present has not been measured.

3.1.6 General Soil Analysis Data Validation Notes

A full list of the data validation notes are provided in Appendix E. Following is a summary of the main discrepancies noted between the expected and actual soil results.

According to method SW-846 9045D, the pH analysis should be performed as soon as possible following sample collection. The laboratory analyzed all soil pH samples 37 to 39 days after collection, and consequently all pH results are qualified as estimated (J).

Select metals results are qualified as estimated (J) when associated matrix spike recoveries, duplicate relative percent differences, and serial dilution percent differences were outside of established control limits.

3.2 Vegetation and Discrete Soil Sampling Results

This section presents the results of the vegetation and discrete soil sampling, including:

- ISM sampling of the dominant vegetation on the ISM soil sampling MSPs, OBDUs, and background areas
- Selenium accumulator species discrete vegetation and co-located soil sampling
- Riparian species discrete vegetation and co-located soil sampling
- Culturally significant species discrete vegetation and co-located soil sampling

3.2.1 ISM Dominant Vegetation Sampling Results

The ISM results of the dominant vegetation sampling are presented in Table 3.2-1. All analytical results are presented as dry weight. The plant species included in each ISM replicate is provided in Appendix G. The RSD and RPD values of the three ISM replicates are presented in relationship to a threshold of 30% difference. In addition, data are presented as box plots for comparison between areas and by collection type (overburden with and without topsoil and mining area) in Appendix G.

Table 3.2-1 provides the 95UCL for the replicate metals ISM vegetation samples collected for Background Area, MSP, and OBDUs. The 95UCL output from EPA's software program ProUCL (V. 5.0) is provided in Appendix G.

3.2.1.1 Mill Shale Piles

Molybdenum and selenium were the only metals exceeding ESLs in dominant vegetation replicate composite samples collected from MSPs (Table 3.2-1; Figures 3.2-1a through 3.2-d). Vegetation on 11 of the 15 MSPs sampled (A-7, B-2, B-4B, CC-2, I-2, HH-4, K2-B, P-2, W-1, X-2, and Z-2) had elevated levels of molybdenum with 95UCLs ranging from 8.84 to 31.22 milligrams per kilogram (mg/kg) compared to the ESL of 5 mg/kg. These same sites also displayed elevated levels during 2015 sampling. Selenium exceeded the ESL (5 mg/kg) at seven sites (A-7, B-2, HH-4, JH-2, W-1, X-2, and Z-2) with UCL concentrations ranging from 5.3 to 86.64 mg/kg. All of these sites with the exception of HH-4 (which slightly exceeded the ESL at a concentration of 5.3 mg/kg) also displayed elevated levels during 2015 sampling. All other MSP dominant vegetation ISM samples had analyte concentrations below screening levels (Table 3.2-1).

3.2.1.2 Overburden Decision Units

Molybdenum and selenium were the only metals exceeding ESLs in dominant vegetation composite samples collected from OBDUs (Table 3.2-1; Figures 3.2-1a through 3.2-1d). Vegetation on 9 of the 15 OBDUs sampled (OBDU-1, OBDU-2, OBDU-4, OBDU-9, OBDU-11, OBDU-14, OBDU-15, OBDU-17, and OBDU-18) had elevated levels of molybdenum with UCLs ranging from 6.91 to 16.65 mg/kg compared to the ESL of 5 mg/kg. Selenium exceeded the ESL (5 mg/kg) at seven OBDUs sampled (OBDU-1, OBDU-2, OBDU-15, OBDU-18, and OBDU-23) with UCL concentrations ranging from 11.9 to 451 mg/kg.

All other OBDU dominant vegetation ISM samples had analyte concentrations below screening levels (Table 3.2-1).

3.2.1.3 Background Areas

All background dominant vegetation ISM samples had analyte concentrations below screening levels (Table 3.2-1).

3.2.2 Selenium Accumulator Species Sampling Results

During 2016, 13 known selenium accumulator species were sampled in disturbed areas and background locations (Figure 3.2-2). A total of 166 samples were collected, which included the following species and number of samples collected in disturbed and background areas (Detailed vegetation results can be found in Table 3.2-2):

- Aster (*Symphtrichum sp)* – 19 samples (9 background)
- Milk vetch (*Astragalus sp*) – 19 samples (10 background)
- Indian paintbrush (*Castilleja sp*) – 19 samples (9 background)
- Toadflax (*Comandra sp*) – 19 samples (10 background)
- Gumweed (*Grindelia sp*) – 19 samples (9 background)
- Snakeweed (*Gutierrezia sp*) – 21 samples (8 background)
- Goldenweed (*Haplopappus sp*) – 21 samples (6 background)
- Woody aster (*Machaeranthera sp*) – 19 samples (7 background)
- Blazing star (*Mentzelia sp*) – 10 samples (0 background)

There were no exceedances of the ESLs in selenium accumulator species for the following metals: antimony, arsenic, barium, beryllium, boron, chromium, cobalt, manganese, mercury, nickel, silver, and thallium.

For the other metals where some exceedances were detected, results were highly variable with no distinct pattern by species and very few samples exceeding ESL concentrations. A summary follows:

- Aluminum (ESL=200 mg/kg) – Exceedances were found in 21 samples in both background locations and disturbed areas. Results were highly variable within species and area sampled. Most of the results ranged from concentrations barely exceeding the ESL to less than 500 mg/kg. One sample of woody aster (*Manchaerantera sp.*) collected from background decision unit BA 2 was 1,300 mg/kg.
- Cadmium (ESL=10 mg/kg) – Exceedances were found in three samples slightly above the ESL with concentrations ranging from 10.7 to 17.6 mg/kg.
- Copper (ESL=15 mg/kg) – Exceedances were found in 10 samples in both background locations and disturbed areas. Results slightly exceed the ESL ranging from 15.2 to 28.3 mg/kg.
- Lead (ESL=10 mg/kg) – Exceedance was in only one sample from a background location.

- Molybdenum (ESL=5 mg/kg) – Exceedances were found in 26 samples from both background locations and disturbed areas. Results ranged from 5 to 36.5 mg/kg.
- Selenium (ESL=5 mg/kg) – Exceedances were found in 12 samples, all from disturbed areas (see Figures 3.2-2a through3.2-2d). Results ranged from 8.48 to 1,190 mg/kg. The four highest concentrations, ranging from 509 to 1,190 mg/kg, were all from samples of gumweed (*Grindella* sp.) and snakeweed (*Gutierrezia* sp.) collected from OBDU-1. Other than those samples, the highest concentration elsewhere was 76.1 mg/kg, also from gumweed.
- Uranium (ESL=1.39 mg/kg) – The ESL was slightly exceeded in only two samples ranging from 1.82 to 4.59 mg/kg.
- Vanadium (ESL=10 mg/kg) – The ESL was exceeded in three samples ranging from 12.4 to 53.2 mg/kg.

3.2.3 Riparian Species Sampling Results

This report section summarizes the results of the riparian vegetation sampling that was conducted at the seven riparian areas described in Section 2.2.3.

3.2.3.1 Onsite and Downstream of Potential Site Impacts - Riparian Areas

3.2.3.1.1 004A: Cattle Pond above O/P Pit

The three dominant riparian vegetation species encountered at the cattle pond above the O/P Pit included alkali buttercup (*Ranunculus cymbalaria*), rush (*Juncus sp*), and sedge (*Carex sp*). All three species had metals concentrations exceeding the ESLs. The results include the following (Table 3.2-3, Figure 3.2-3a):

- Alkali buttercup: aluminum (459 mg/kg), molybdenum (6.3 mg/kg), and selenium (6.02 mg/kg)
- Rush: aluminum (529 mg/kg), manganese (455 mg/kg), and selenium (6.32 mg/kg)
- Sedge: aluminum (288 mg/kg)

3.2.3.1.2 013: A-12 Pit Lake

The one dominant riparian vegetation species encountered at the A-12 Pit Lake was cattail (*Typha latifolia*). Metals concentration were detected above ESLs for manganese (1140 mg/kg) and selenium (14.8 mg/kg; Table 3.2-3, Figure 3.2-3b).

3.2.3.1.3 025: Z Pit Lake

The three dominant riparian vegetation species encountered at the Z Pit Lake included American speedwell (*Veronica americana)*, willow (*Salix* sp.), and cattail. Results from these collections recorded metals levels higher than ESLs for cattail and willow. The results include the following (Table 3.2-3, Figure 3.2-3c);

- Cattail: manganese (408 mg/kg), molybdenum (48.9 mg/kg), and selenium (14.6 mg/kg)
- Willow: manganese (1,380 mg/kg) and selenium (5.19 mg/kg)

3.2.3.1.4 030: East Limb North Pond / Holding pond below “Y” intersection

The three dominant riparian vegetation species encountered at the East Limb North Pond included water knotweed (*Persicaria amphibia*), water plantain (*Sagitaria sp*), and white dock (*Rumex triangulivalvus*). All three species had metals concentrations exceeding the ESLs. The results include the following (Table 3.2-3, Figure 3.2-3b and c):

- Water Knotweed: aluminum (574 mg/kg) and manganese (802 mg/kg)
- Water Plantain: aluminum (316 mg/kg)
- White Dock: aluminum (534 mg/kg)

3.2.3.1.5 040: Seep east of OBDU-11

The three dominant riparian vegetation species encountered at the seep east of OBDU-11 included American speedwell, sedge, and willow. Of these species collected, only American speedwell had aluminum levels above ESLs at 640 mg/kg (Table 3.2-3, Figure 3.2-3c). A field duplicate of the sedge resulted in levels of aluminum above ESLs at 258 mg/kg. Concentrations of all other metals were less than ESLs in the remaining samples.

3.2.3.1.6 037: Willow Creek

The three dominant riparian vegetation species encountered at Willow Creek included American speedwell (*Veronica americana*), false lupine (*Thermopsis montana*), and willow. Of these species collected, American speedwell had aluminum levels higher than ESLs at 298 mg/kg (Table 3.2-3, Figure 3.2-3d). Concentrations of all other metals in these samples were less than ESLs.

3.2.3.2 Background Riparian Areas

3.2.3.2.1 014: Big Willow Springs

The three dominant riparian vegetation species encountered at Big Willow Springs included willow (*Salix sp*), Chokecherry (*Prunus virginiana*), and stinging nettle (*Utrica dioica*). Of these species collected, only one sample, willow, had zinc levels slightly higher than ESL (300 mg/kg) at 325 mg/kg (Table 3.2-3, Figure 3.2-3b). Concentrations of all other metals were less than ESLs in the remaining samples.

3.2.3.2.2 020: Big Springs

The three dominant riparian vegetation species encountered at Big Springs included currant (*Ribes sp*), willow, and seep monkeyflower (*Mimulus gutattas*). Of these species collected, seep monkeyflower had aluminum levels higher than ESLs at 838 mg/kg (Table 3.2-3, Figure 3.2-3d). Concentrations of all other metals were less than ESLs in the remaining samples.

3.2.3.2.3 031: Portneuf River above U Creek

The three dominant riparian vegetation species encountered at the Portneuf River above U Creek included rush, sedge, and willow. Of these species collected, the rush had aluminum and copper levels higher than ESLs at 273 and 20.5 mg/kg, respectively (Table 3.2-3, Figure 3.2-3a). Concentrations of all other metals were less than ESLs in the remaining samples.

3.2.4 Culturally Significant Species Soil Sampling Results

Thirteen culturally significant vegetation species were collected during 2016. In some instances, more than one plant part was collected during 2016 to assess the various parts of the plants that are reportedly used. The results of these species collections including comparisons of metal concentrations with ESLs are provided in Table 3.2-4 and as boxplots in Appendix G. Species collected, parts of the plants, and numbers of samples are as follows:

- Arrowleaf Balsamroot – Roots/Seed (*Balsamorhiza sagittata*; 16 samples total)
- Big Sagebrush (*Artemisia tridentata*; 8 samples)
- Canada Thistle – Leaves/Stems (*Cirsium arvense*; 16 samples)
- Chokecherry (*Prunus virginiana*; 5 samples)
- Common Yarrow (*Achillea lamulosa*; 8 samples)
- Dandelion – Flowers/Leaves/Roots (*Taraxacum officinale*; 24 samples)
- Desert Parsley (*Lomatium dissectum*; 9 samples)
- Golden Current (*Ribes aurum*; 2 samples)
- Juniper (Juniperus sp; 9 samples)
- Rabbit brush (*Chrysothamnus nauseosus*; 8 samples)
- Serviceberry (*Amelanchier alnifolia*; 8 samples)
- Tarragon (*Artemisia dracunculoides*; 9 samples)
- Wild Rose (*Rosa sp*; 8 samples)

There were many exceedances of measured metals concentrations above the calculated HHSL for plant ingestion. The plants collected are shown in Figures 3.2-4 through 3.2-4d. The text in this section highlights some of the overarching trends to the data without listing all of the specific exceedances by species and area. All results are presented in Table 3.2-4 in mg/kg dry weight units and compared to the HHSLs.

All eight arrowleaf balsamroot root samples collected during 2016 had metals concentration above HHSLs. Nearly all root samples had exceedances of 17 of the 20 metals which were analyzed. Detailed results of the root samples for arrowleaf balsamroot are provided in Table 3.2-4. All eight of the arrowleaf balsamroot seed samples collected during 2016 also had metals concentrations above HHSLs. Nearly all seed samples had exceedances of 18 of the 20 metals which were analyzed. Most metals concentrations were higher in roots than seeds, with the exception of boron, copper, and zinc which were higher in the seeds in some samples. Barium and lead were present at levels greater than HHSLs in all of the root samples collected, but only potentially present in one of the seed samples above HHSLs due to an elevated detection level for lead of 1.4 mg/kg (Table 3.2-4).

Every sample of big sagebrush foliage collected during 2016 had a metal concentration above HHSLs. Nearly all of the samples had exceedances for 12 of the 20 metals which were analyzed, with five additional metals exceedances in a small number of samples (Table 3.2-4).

A total of eight leaf samples were collected from Canada thistle in 2016. The majority of the leaf samples had metals concentration above HHSLs for 12 of the 20 metals analyzed. Some leaf samples also had exceedances for an additional seven metals (Table 3.2-4). A total of eight stem samples were collected from Canada thistle in 2016. The majority of the stem samples had metals concentrations above HHSLs for 11 of the 20 metals analyzed. Some stem samples also had exceedances for an additional three metals (Table 3.2-4). Metals concentrations were generally higher in Canada thistle leaves than in stems for most metals. However, copper and thallium concentrations were higher in stems in several samples.

A total of five samples of chokecherry berries were collected during 2016, and all five samples had a metals concentration above HHSLs. The majority of samples had metals concentrations above HHSLs for eight metals. Three samples had exceedances of other metals (Table 3.2-4).

The samples of common yarrow foliage collected during 2016 all had a metals concentration above HHSLs. Nearly all of the samples had exceedances for 14 of the 20 metals which were analyzed, with four additional metals exceedances in a small number of samples (Table 3.2-4).

A total of 24 dandelion samples (8 samples each of flowers, leaves, and roots) were collected during 2016. All eight of the dandelion flowers collected had a metals concentration above HHSLs (Table 3.2-4). Most of the flower samples had exceedances for 12 of the 20 metals which were analyzed, with three additional metals exceedances in a small number of samples (Table 3.2-4). Most of the leaf samples had exceedances for 16 of the 20 metals which were analyzed, with two additional metals exceedances in a small number of samples (Table 3.2-4). Most of the root samples collected had exceedances for 17 of the 20 metals which were analyzed, with three additional metals exceedances in a small number of samples (Table 3.2-4). Concentrations of most metals are highest in the dandelion roots, followed by leaves, with lowest concentrations in flowers. Boron concentration were highest in the flowers and lowest in the roots for most samples. Selenium, thallium, manganese, and molybdenum concentrations were highest in the leaves in several samples.

A total of nine samples of desert parsley root were collected during 2016, and every samples collected had a metals concentration above HHSLs (Table 3.2-4). Nearly all of the samples had exceedances for 17 of the 20 metals which were analyzed.

Two samples of golden current berries were collected. One sample had metals concentrations above HHSLs for seven metals, and the other sample had metals above HHSLs for nine metals (Table 3.2-4).

A total of nine samples of juniper berries were collected, and all of the samples had metals concentrations above HHSLs. Nearly all samples had metals exceedances for 7 of the 20 metals, with an additional three metals exceedances for some samples (Table 3.2-4).

Rabbit brush foliage was collected from eight samples in 2016, and all of the samples had metals concentrations above HHSLs. Nearly all samples had metals exceedances for 15 of the 20 metals, with one additional metal exceedance for some of the samples (Table 3.2-4).

A total of eight samples of serviceberry berries were collected during 2016, and all of the samples had metals concentrations above HHSLs. Nearly all samples had metals exceedances for 11 of the 20 metals, with two additional metals exceedances for some of the samples (Table 3.2-4).

A total of nine samples of tarragon seeds were collected during 2016, and all of the samples had metals concentrations above HHSLs. Nearly all samples had metals exceedances for 10 of the 20 metals, with five additional metals exceedances for some of the samples (Table 3.2-4).

During 2016, a total of eight samples of wild rose foliage were collected, and all of the samples had metals concentrations above HHSLs. Nearly all samples had metals exceedances for 9 of the 20 metals, with an additional three metals exceedances for some of the samples (Table 3.2-4).

Box plots provided in Appendix G show that overall, the metal concentrations in dandelion (*Taraxacum officinale)* roots and leaves tend to be higher than the other plants sampled.

3.2.5 Soil-to-Plant Uptake Factors

3.2.5.1 ISM Dominant Vegetation Uptake (Early Growing Season)

The soil-to-plant uptake factors for the ISM dominant vegetation sampled in the early growing season, and the new OBDUs sampled in both the early and late growing season are presented in Table 3.2-5. The only analytes with an uptake ratio greater than 1.0 were boron, molybdenum, selenium, and silver. The spring uptake values are comparable to the fall values as reported in the 2015 DSR (Golder 2016a), with the same analytes exceeding an uptake ratio of 1.0.

3.2.5.2 Selenium Accumulator Species Uptake Factors

The co-located soil data associated with the selenium accumulator species are shown in Table 3.2-6. The soil-to-plant uptake factors are presented on Table 3.2-7. Generally, most plants have an uptake ratio less than 1.0 for most metals except for boron, molybdenum, and silver. There were some plants that accumulated selenium to concentrations greater than that in soil, but this was sporadically observed across the site. The highest accumulation of selenium was about 15 times the soil concentration in a snakeweed plant collected from OBDU-1. The average soil to plant uptake factor for snakeweed collected in the disturbed areas was about 1.3. The only other plant with an average selenium soil to plant uptake factor greater than 1.0 was gumweed, with an average of about 1.4. These results are comparable to the fall uptake ratios reported in the 2015 DSR (Golder 2016a), with the most common metals with an uptake ratio greater than 1.0 being boron, molybdenum, and silver, with some plants having an uptake ratio greater than 1.0 for cadmium, copper, mercury, and selenium.

3.2.5.3 Riparian Species Uptake Factors

The co-located soil data associated with the riparian species are shown in Table 3.2-8. The soil to plant uptake factors are presented on Table 3.2-9. The riparian plants tended to have uptake factors greater than 1.0 for copper, manganese, and zinc in samples where riparian plants concentrations were greater than screening levels. About half of the other metals had uptake factors greater than 1.0. None of the aluminum or the cadmium uptake factors were greater than 1.0. Three of the six plants whose vegetation concentrations exceeded selenium screening levels had a soil to plant uptake factor less than 1.0 (willow, cattail, and rush) while an alkali butter cup and two other cattails had selenium uptake factors greater than 1.0.

3.2.5.4 Culturally Significant Species Uptake Factors

The co-located soil data associated with the culturally significant plant species collected from disturbed areas are shown in Table 3.2-10. The soil to plant uptake factors are presented on Table 3.2-11. As with the selenium accumulators, most plants have an uptake ratio greater than 1.0 for boron. However, there were also many plants that had an uptake ratio greater than 1.0 for molybdenum, selenium, and silver. The highest soil to plant uptake ratios for selenium were for a thistle plant collected near the A12 pit, at about 82 for the leaves and 10 in the stem.

3.2.6 General Vegetation and Discrete Soil Analysis Data Validation Notes

A full list of the data validation notes are provided in Appendix E. The equipment blanks associated with the vegetation and soil collections are shown on Table 3.2-12. Following is a summary of the main discrepancies comparing the expected and actual methods and results for the vegetation data.

All soil samples in SDGs K1608375, K1608421, K1608423, K1608425, K1608427, K1608573, K1608574, K1608575, and K1612896 were analyzed for TOC more than 56 days after collection. This is greater than two times the recommended hold time of 28 days and is considered a gross hold time exceedance, and thus all TOC results in these SDGs are rejected. However, TOC is not a critical parameter for testing in soils where the primary COPCs are inorganic.

All soil pH results are qualified as estimated (J) for exceeding the hold time because the method calls for pH analysis immediately upon sample collection. Vegetation samples are not subject to the same hold time requirements and are not qualified based on hold time.

Numerous metals results are qualified as either non-detect (U) or estimated (J) due to varying types of blank contamination. Blank contamination is common in metals analyses.

Some molybdenum results are qualified as estimated with low bias (J-) due to low recovery of the associated initial calibration verification sample.

3.3 Surface Water Results

Surface water samples were collected from 35 sites, 15 more sites than were sampled in fall of 2015 due to presence of water. For quality control purposes two duplicates were collected and two MS/MSD volumes, as well as two blanks. No decontamination was required for this sampling effort as all materials used were disposable. Surface water samples consisted of filtered and unfiltered samples. Filtered samples were analyzed for dissolved analytes and unfiltered samples were evaluated for total analyte analysis. Results are presented in Tables 3.3-1 and 3.3-2, for total and dissolved fractions respectively, along with the ESLs and HHSLs. General water chemistry results are provided in Table 3.3-3. In-situ measurements for conductivity, dissolved oxygen, oxidation-reduction potential, pH, temperature, turbidity, and flow were collected at all water sample sites and are presented in Table 3.3-4. Figures 3.3-1a through 3.3-4d show surface water sampling results that exceed ESLs. Figures 3.3-1e through 3.3-1h show surface water sampling results that exceed HHSLs.

The tables also provide a description of the waterbody types. Categories were made more inclusive and anything referred to as a seep is listed as a spring as they are very similar hydrologic features. Ponds are distinguished from pit lakes as they were not formed from mining operations or were naturally occurring. Only one river (Portneuf) is present in the study area, all other flowing waters are listed as streams, unless otherwise designated as springs.

There is high variability with comparisons between fall 2015 and spring 2016 sampling results (Tables 3.3-5 and 3.3-6). Across sites one constituent may be in greater concentration during fall or spring and the pattern is not consistent between sites; for example it is not possible to say that total selenium is elevated at all sites in the spring. Although, in general this is true, and the greatest variation between fall and spring sampling was at A12 Pit Lake (Site 013), with 188 µg/L in the spring sample and 7.6 µg/L in the fall sample. The fall 2015 sample at A12 was very similar to Cattle Pond A (site 004A), but the cattle pond had a reduced selenium concentration in spring 2016. This pattern is also true for dissolved constituents. At one site constituents are not consistently elevated or reduced depending on time of year. For example, at the Portneuf River above U Creek (site 031), total aluminum is elevated in spring, while boron and arsenic are elevated in the fall. Consistent with previous sampling, there is no definitive pattern between onsite and offsite sampling locations, samples from both areas may have exceedances for both ecological and HHSLs.

3.3.1 Surface Water Results Compared to Ecological Screening Levels

Dissolved arsenic and boron exceeded ESLs at the majority of sites and dissolved barium at all sampled locations both on and off site. The spring at BB-2 (Site 045) and the catch basin northeast of OBDA 11-2 (site 041) were not sampled in fall of 2015 and were the locations with the highest dissolved arsenic. In fall of 2015 concentrations of dissolved arsenic at background locations were comparable to sites affected by mining, during the spring 2016 sampling event, some sites affected by mining were significantly elevated for dissolved arsenic in comparison to background sites. Dissolved cadmium and copper were in exceedance at a few locations, all on disturbed or downgradient sites in the eastern and northern areas of the Site. Only one of the sites (site 040) was sampled in both fall of 2015 and spring of 2016 which exceeded the dissolved cadmium ESL, with concentrations in spring 2016 higher than the fall 2015 sample. None of the sites in exceedance for dissolved copper were sampled in fall 2015. Total selenium was in exceedance at 17 monitoring locations on disturbed areas or downgradient of disturbed areas and four sites upgradient of disturbed areas. Total selenium was highest in the A12 Pit Lake, at 188 µg/L. A new site (048) was sampled downgradient from a historically elevated location (site 040) and total selenium reduced from 21.6 to 17.7 µg/L moving downgradient. Dissolved uranium was in exceedance only downgradient or on disturbed areas, except for Pond #3 (site 010-the clean water reservoir upgradient of the A12 pit), which is considered upgradient of known disturbed areas. Total aluminum was in exceedance at a number of locations, both disturbed and background, with the highest values being onsite. Total aluminum was variable between sites and time of year. In fall 2015, the most concentrated location for aluminum was the East Limb north pond (site 030), whereas in spring 2016 the highest concentration was at Ross Fork Creek (site 018). Alkalinity is in exceedance at all sampled locations both on and offsite. Conductivity was also in exceedance at most sites, and inclusive of both disturbed and non-disturbed locations.

3.3.2 Surface Water Results Compared to Human Health Screening Levels

Human health exceedances are only related to total fraction analysis, general chemistry, and field parameters. No human health screen levels apply to dissolved fraction analysis.

At all locations, both on and off disturbance, samples exceeded HHSLs for arsenic and boron; this was the same in 2015. Arsenic and boron were both variable between sites, with some locations being elevated in fall and some in spring. Many sites on disturbed and background areas are also in exceedance for iron. Iron appeared to be elevated at streams in the spring and at lakes/ponds in the fall. The A12 Pit Lake and Pond #3 were not in exceedance for iron during spring 2015 sampling, but were in exceedance in fall 2015. Ten locations were in exceedance for cadmium, all of which were on disturbed or downgradient areas. One location, the catch basin northeast of OBDA 11-2 (site 041) was significantly higher than other sites at 29.7 µg/L. Site 041 was also the only site in exceedance for total chromium and trivalent chromium (Cr+3), and one of only a few disturbed sites in exceedance for hexavalent chromium (Cr+6), cobalt, copper, lead, nickel, silver, and zinc. This site was dry in 2015 and thus not sampled to provide a comparison between fall and spring at this location. Many sites are also in exceedance for total dissolved solids (TDS).

3.3.3 General Surface Water Analysis Data Validation Notes

A full list of the data validation notes are provided in Appendix E. Following is a summary of the main discrepancies comparing the expected and actual methods and results for the surface water data.

All pH results are qualified as estimated (J) for exceeding the hold time because the method calls for pH analysis immediately upon sample collection.

Certain metals results were qualified as non-detect (U) or estimated with high bias (J+) due to varying types of blank contamination. Blank contamination is common in metals analyses.

The metals results from sample SW-040-051316-U-1 and the TOC and total kjeldahl nitrogen (TKN) results from sample SW-043-051316-U-1 were qualified as estimated (J/UJ) because the sample bottles were received with pH>2.

3.4 Bird Mud Nest Material Sampling Results

Two of the locations sampled were in proximity to OO-3 pit and were not taken from actual nest material, rather they were composite samples from muddy areas in the vicinity of the nests. These two locations were in exceedance for arsenic, cadmium, chromium, copper, nickel, selenium, silver, vanadium, and zinc (Table 3.4-1). Only one of the samples was in exceedance for lead.

The third sample was collected directly from nest material at the tire shop in headquarters (Table 3.4-1). This sample was higher in selenium than the other two samples. This sample was in exceedance for the same constituents as the OO-3 pit samples, except for arsenic, nickel, and silver.

3.4.1 General Bird Nest Material Analysis Data Validation Notes

A full list of the data validation notes are provided in Appendix E. Following is a summary of the main discrepancies comparing the expected and actual methods and results for the bird nest material data.

The total solids analyses of all three samples exceeded hold time requirements, and thus the results are qualified as estimated (J). Further estimated (J) qualifiers were applied to various metals results due to matrix spike recoveries, duplicate relative percent differences, and serial dilution percent differences that were outside of acceptance limits.

All antimony results were qualified as estimated (J) when there was low matrix spike recovery due to recognized issues with the EPA Method 3050B digestion procedure. This procedure was selected as it is a widely applicable digestion procedure and was used, with one exception for mercury, for all metals in the sediment samples. Alternative methods of digestion are available for antimony.

3.5 Groundwater Results

Groundwater samples were collected May 23 to 25, 2016 from the three perched zone monitoring wells (MW-JF2-1, MW-S6-1, and MW-SA1-1) and one shallow alluvial well (MW-TM1) installed during the fall of 2015 in the South 40. Monitoring well MW-S40-3, also located in the South 40 and installed in the Wells Formation, was completed during fall 2016 and sampled on November 8, 2016. Both total and filtered samples were collected. Results are presented in Table 3.5-1 along with comparisons to HHSLs. Sampling results from 2015 are provided to allow comparison with the 2016 data (Table 3-5.1). For some parameters, the 2016 water quality in the perched groundwater wells was similar to the 2015 results. But there is variability in other parameters, with some concentrations being higher in spring 2016 and others being lower in spring 2016. A few examples are provided below:

- At MW-JF2-1, dissolved arsenic increased from 1.2 µg/L in fall 2015 to 6.3 µg/L in spring 2016.
- At MW-JF2-1, dissolved hexavalent chromium decreased from 0.154 µg/L in fall 2015 to 0.044 µg/L in spring 2016.
- At MW-S6-1, dissolved iron increased from below detection (<0.3 µg/L) in fall 2015 to 42.3 µg/L in spring 2016.
- At MW-S6-1, dissolved lead decreased from 0.215 µg/L in fall 2015 to 0.004 µg/L in spring 2016.
- At MW-TM-1, dissolved arsenic increased from 0.101 µg/L in fall 2015 to 0.6 µg/L in spring 2016.

3.5.1 Groundwater Results Compared to Human Health Screening Levels

The majority of the 2016 water quality met HHSLs, with the following exceptions:

- One sample was above screening levels for gross alpha and chloride.
- Two samples were above screening levels for aluminum, selenium, and zinc.
- Three samples were above screening levels for nickel, vanadium, and TDS.
- Four samples were above screening levels for cadmium, cobalt, iron, and uranium.
- Six samples were above screening levels for manganese and gross beta.
- Eight samples were above screening levels for thallium.
- All samples (five wells, total and dissolved fractions) were above screening levels for arsenic and hexavalent chromium.

3.5.2 Groundwater Results Compared to Maximum Contaminant Levels

The majority of the 2016 water quality were below maximum contaminant levels (MCLs), with the following exceptions:

- The secondary MCL of 300 µg/L for iron was exceeded in the total fraction samples collected in all wells except MW-TM-1.
- The secondary MCL of 50 µg/L for manganese was exceeded in MW-JF2-1 (total and dissolved), MW-S6-1 (total and dissolved), and MW-S40-3 (total and dissolved).
- The MCL of 15 pci/L for gross alpha was exceeded in MW-SA1-1 (total and dissolved).
- The MCL of 4 picocuries per liter (pci/L) for gross beta was exceeded in MW-JF2-1 (total), MW-S6-1 (total and dissolved), MW-SA1-1 (total and dissolved), and MW-TM1-1 (dissolved).
- The secondary MCL of 250 mg/L for chloride was exceeded in MW-S6-1 (total).
- Two samples (MW-JF2-1 and MW-S6-1) were below the minimum secondary MCL for pH (6.5 standard unit [su]).

3.5.3 General Groundwater Analysis Data Validation Notes

The full data validation summary is provided in Appendix E. Following is a summary of the main issues that resulted in the data being qualified.

All pH results and the total and dissolved orthophosphate results of samples GW-MWS61-052516-U-1 and GW-MWJF21-052516-U-1 were analyzed outside of hold time requirements and were qualified as estimated (J). The samples were analyzed within 5 hours of the 48 hour hold time for total and dissolved phosphate, so sample quality is not expected to be affected. All hexavalent chromium samples in SDG K1605542 were initially analyzed within hold time, but the results demonstrated poor peak integration. The lab later reanalyzed the samples out of hold time. The results of the original analysis are not reported, while the results of the reanalysis are reported and qualified as estimated (J).

Certain metals results were qualified as non-detect (U) or estimated with high bias (J+) due to varying types of blank contamination. Blank contamination is common in metals analyses.

Other sample results were qualified due to laboratory QC criteria. Certain results from SDG K1605695 were qualified as estimated (J/UJ) when the field duplicate failed precision criteria. Molybdenum results in samples GW-MW-S403-110816-F-1 and GW-MW-S403-110816-U-1 were qualified as estimated with low bias (J-) due to low initial calibration verification sample recovery. Hexavalent chromium results in the same samples were also qualified as estimated with low bias (J-) due to low matrix spike recovery.

3.6 Overall Data Validation Notes

Recalculation checks were performed on the following seven SDGs: K1605175, K1605466, K1606197, K1606522, K1608574, K1610313, and K1610361. This satisfies the requirement to perform recalculation checks on 10% of all received SDGs. The recalculation checks confirmed the accurate calculation of results by the lab.

In total, 104 results were rejected. These rejections were due to gross hold time exceedances of the TOC analyses of all the discrete soil samples in nine SDGs. This corresponds to an overall data completeness of greater than 99%. TOC results are not of great concern when dealing with COPCs that are inorganics.

All laboratory pH analyses for all samples were done outside of hold time because the hold time is 15 minutes and can never be met by the lab. All lab analyzed pH results were qualified as estimated (J), and no further action can be taken. Note that water samples (surface and ground) had field measurements of pH taken during sample collection, and the laboratory results were comparable to the field results.

Comparable level of metals contamination were found in field blanks, method blanks, and initial/continuing calibration blanks, which demonstrates that contamination is an issue even when using laboratory grade deionized water. Data was qualified for blank contamination in accordance with the EPA National Functional Guidelines, which do not require outright rejection of data in the presence of relatively low contamination. Rather, very low sample detections associated with blank contamination are qualified as non-detected (U) or estimated (J/J+), while associated non-detections and detections sufficiently greater than the blank contamination are not qualified. Results are considered usable and defensible when qualified appropriately.

There were several results that were qualified due to laboratory QC failures, such as poor spike recovery. QC failures such as these are common and expected in laboratory data. Associated results are still considered usable and defensible when qualified appropriately.

4.0 SUMMARY OF PROPOSED WORK FOR 2017

Work proposed for 2017 include the following:

- Background vegetation samples for culturally significant species – Analytical results of the sampling of culturally significant vegetation species collected from disturbed areas at Gay Mine during 2016 indicate exceedances for several of the COPCs compared with calculated HHSLs. Therefore, sampling of these species from background areas is required to determine concentrations in areas unaffected by mining activities. Sampling will be conducted for the same species and plant parts as were collected from disturbed areas as described in the Draft 2016 RIWP Addendum (Golder 2016b). A description of the proposed investigations will be provided in a Technical Memorandum.
- Groundwater monitoring well drilling and installation – The 2016 RIWP Addendum included six new monitoring wells. However, during the 2016 field season only well MWS40-3 located in the South 40 was completed. Well MWS40-1 was drilled to 167 feet bgs before drilling ceased for the year. Drilling and installation of MWS40-1 and the other four wells proposed in the 2016 RIWP (MWS40-3, MWSPNL-1, MWSPNL-2, and MWSPNL-3) will be conducted in 2017. This work has already been approved and will begin as soon as the site is accessible for drilling equipment in the spring of 2017.
- Investigation of distressed or dead cattle – a protocol has been prepared to investigate distressed or dead cattle if encountered at the Gay Mine site (Golder 2017). While this will be performed outside the scope of the RI, Golder and the companies have prepared a protocol to standardize the investigation and reporting of distressed or dead cattle on the Site.
- Screening level risk assessment – The biotic and abiotic samples collected in 2015 and 2016 will be used to conduct a screening level human health and ecological risk assessment according to the methods provided in Appendix B to Golder (2014). This will be used to determine the need for potential future sampling of biotic or abiotic samples (including future sampling of overburden soils) and ensure that future collections will be used to support filling risk assessment data needs.
- As a result of the past few years of low winter snowfall the A12 Pit had virtually dried up by the fall of 2016. The Companies are considering conducting an Early Action to divert water discharges from the former water supply reservoir (Pond 1) to prevent it from entering Pond 2 and the A12 Pit where it picks up contamination. Snowfall during the winter of 2016/2017 has been greater than recent years at the Gay Mine. Increased runoff during the spring of 2017 is expected to again discharge to the A12 pit. Discharge volume will be measured to provide information for design of a diversion system. Information will also be obtained on water quality and water depth in the A12 pit resulting from the 2017 surface water runoff.

5.0 CLOSING

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